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Editorial

Extraction and Analysis of Natural Product in Plant

Gerardo F. Barbero

Department of Analytical Chemistry, Faculty of Sciences, University of Cadiz, Agrifood Campus of International Excellence (ceiA3), IVAGRO, 11510 Puerto Real, Spain; gerardo.fernandez@uca.es; Tel.: +34-956-016-355

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Plants are well known for being a major source of natural compounds, many of them generally considered of biological interest for their antioxidant, anti-inflammatory, antimicrobial or anti-cancerogenic properties. A large number of such source plants and their extracts are commonly used in the agri-food, pharmaceutical or agrochemical industries. A variety of techniques are employed for the extraction of these natural compounds from plants, and all such techniques are required to meet a double target: (i) to extract the compounds in order to determine their presence in plant matrices; and (ii) to obtain compound extracts that contain a large proportion of the substances of interest in each particular case. This Special Issue entitled "Extraction and Analysis of Natural Product in Plant" is based on a wide compilation from a total of 16 other works (14 articles, 1 review and 1 communication) and intends to enlighten the current state of the art regarding the extraction, identification, analysis and usage of natural plant compounds and their extracts, as well as their usage and implementation for different purposes.

Conventional extraction techniques such as maceration, Soxhlet extraction, percolation, reflux extraction, and distillation have traditionally been used to obtain extracts from plants. These techniques present a series of disadvantages such as their cost, heavy use of solvents, long extraction times or low extraction yields. In recent decades, new, more rapid and efficient extraction methodologies have been developed that minimize the use of solvents, shorten extraction times and maximize extraction yields while preventing the risk of degrading the compounds of interest. These new techniques include ultrasound-assisted extraction (UAE), microwave assisted extraction (MAE), pressurized liquid extraction (PLE) and supercritical fluids extraction (SFE), among others.

This Special Issue comprises several articles on the extraction of compounds of biological interest from plants by means of non-conventional extraction techniques. Many of these methods have been developed by optimizing the extraction variables based on the results obtained from experimental designs. The purpose of experimental designs is to determine, through the reduction in the extraction conditions, the optimal variable values to maximize extraction results. Such designs also provide information on the correlations between the different extraction variables. González-de-Peredo et al. [1] optimized an analytical method for the extraction of the total phenolic compounds and anthocyanins from sloes (*Prunus spinosa* L.) using ultrasound-assisted extraction (UAE). For this purpose, a six-variable response surface design (Box–Behnken) was used. Aliaño-González et al. optimized the extraction of individual anthocyanins and total phenolic compounds from açai (*Euterpe oleracea* Mart.) using several non-conventional extraction techniques such as ultrasound-assisted extraction (UAE) [2], microwave-assisted extraction (MAE) [3] and pressurized liquid extraction (PLE) [4]. These three studies also employed response surface designs (Box–Behnken) for the optimization of the different variables, including optimal extraction times and the validation of the methods themselves. All these three extraction techniques were developed for the characterization of açai fruits, as well as for the analysis of the food products elaborated using this fruit. Thanks to these non-conventional methods, the time required for a substantial extraction of the compounds of interest was reduced to just a few minutes (2–10 min). Aurach et al. [5] used both ultrasound-assisted extraction (UAE) and microwave-assisted extraction (MAE) for the extraction of the phenolic compounds that are found in Cotton-Lavender (*Santolina chamaecyparissus* L.). The largest phenolic compounds' extraction yields from this matrix were achieved when MAE was employed. All of these methods that have been mentioned were based on an analytical approach to determine the quality of the raw material for possible uses in the food and pharmaceutical industry, as well as for the quality control of industrial processes.

In addition to the analytical approach, the development of methods for the extraction of compounds either because of their biological activity or for their high added value, may have industrial purposes. In this sense, the objective would be to obtain extracts at an industrial level that could be subsequently used for other purposes, such as the making of food, pharmaceutical products, or other industrial uses. Setyaningsih et al. [6] optimized ultrasound-assisted extraction to improve the current cassava (*Manihot esculenta* Crantz) starch production by conventional maceration. The use of UAE resulted in a starch of superior purity and lower viscosity than the regular commercial samples. This novel extraction technique not only accelerated the extraction process, but also modified the starch by altering its granule size when extracted at the highest temperature in the study (70 °C) to provide it with a lower viscosity (1920 cP) than that of regular commercial samples (1996 cP). Skrypnik and Novikova [7] optimized the extraction of polyphenols from apple pomace based on nonionic emulsifiers. The proposed extraction technology based on the use of an aqueous solution of nonionic emulsifiers allowed to obtain extracts with high polyphenol contents which are suitable for certain applications in food, cosmetic and pharmaceutical industries where a surfactant is required as a stabilizing agent. Catania et al. [8] compared the effects of the different extraction technologies on the quality of pomegranate juice. The aim of this study was to evaluate the influence of the pressing process on the properties of the final pomegranate juices, in terms of pressure level, duration of the pressure applied and juice yield, and then determine the influence of the pressure level on the volatile and nutraceutical properties of the different juices that were obtained. Their study confirmed that the application of different pressure levels during the extraction process of the pomegranate juice resulted in products of different quality. Scarano et al. [9] obtained natural dyes from vegetable waste matrices using the prickly pear peels of *Opuntia ficus-indica* (L.) Miller. In their work, the effect of the Naviglio method (an eco-innovative solid–liquid extraction technique) on the extracted dyes was investigated. The results revealed that the extracts obtained by the Naviglio method were richer in pigments than those obtained through traditional methods, which proved the usefulness of these extracts as a natural source of dyes.

A very important aspect when it comes to obtaining extracts from plant material involves their chemical characterization, as well as evaluating their properties of interest, such as antioxidant capacity or other pharmacological properties. Plants can produce a large number of chemical compounds, many of them having highly beneficial properties, or interesting functions in the food, cosmetic or pharmaceutical industries, among others. Once these extracts have been obtained, their characterization is of paramount importance in order to determine their composition and quality. It is also necessary to investigate new sources of bioactive natural compounds, as consumers are becoming more and more concerned about the quality of foodstuffs. Fruits and berries from horticultural plants, as well as other plant parts, are known to be good sources of beneficial agents for human well-being and could also be used as natural preservatives in the food industry. Kubczak et al. [10] studied the bioactive compounds and antiradical activity of the *Rosa canina* L. leaf and twig extracts. They analyzed the chemical composition of these extracts and measured their in vitro activity. The HPLC analysis of their phenolics, vitamins and amino acids' contents revealed that both the leaf and the twig extracts were rich in bioactive compounds that exhibited potent antioxidant properties, thereby suggesting that both extracts could serve as non-toxic sources of bioactive compounds with antiradical properties. Sancho-Galán et al. [11] performed a physicochemical and nutritional characterization of oenological lees to be used as a new food ingredient. In addition, the technological properties of such wine lees were also analyzed. The lees analyzed revealed an interesting nutritional composition. In addition, the wine lees presented high values of emulsifying capacity. Thus, wine lees could be considered, in principle, as a new ingredient to be incorporated in new food formulations. Qi et al. [12] in their review, addressed a study on the bioactive compounds, therapeutic activities and applications of *Ficus pumila* L. A number of studies have confirmed that *Ficus pumila* L. has multiple therapeutic properties such as antioxidant, anti-inflammatory, antibacterial, antitumoral, hypoglycemic and cardiovascular benefits, which demonstrates its wide potential application in the food industry.

It is also very important to highlight that counting on rapid and effective methods for the analysis of the bioactive compounds that can be obtained from plants would contribute to determining the properties of both plants and extracts. In this sense, the production of beneficial compounds could be optimized, either by determining the exact moment during the fruit or plant maturation process when the concentration of these compounds is at its maximum level, or by optimizing the methods to provide the plants with the appropriate light, humidity or temperature conditions, for instance, to favor the biosynthesis of the compounds of interest in each particular case. In this sense, Vázquez-Espinosa et al. [13] completed a study on the evolution of capsiate contents along the maturation stages of four chili pepper genotypes (*Capsicum* spp.). The same authors also presented a study of the evolution of capsaicinoids and capsiate throughout the ripening of Naga Jolokia peppers [14]. The conclusions reached as a result of these works would allow farmers to harvest peppers according to their desired (generally maximum) content of the compounds of interest. In this case, it would correspond to the moment when the content of pungent compounds would be at its most. Han et al. [15] compared flavonoid profiles in wheat lines subjected to radiation (*Triticum aestivum* L.). In their study, the original cultivar gave rise to 35 mutant wheat lines through gamma-irradiated breeding. Different phytochemical profiles were determined for each different wheat line, with some of them presenting a larger amount of flavonoids. Similarly, Miao et al. [16] studied the influence of UV radiation on the production of free terpenes in *Vitis vinifera* cv. Shiraz. It is well known that the biosynthesis of these plant secondary metabolites depends on a number of physiological and environmental factors, such as the phenological stage of the vines and their exposure to sunlight. The study provided useful information for grape growers to improve their management of grape terpene composition by UV shading the grapevines.

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References

1. González-de-Peredo, A.V.; Vázquez-Espinosa, M.; Espada-Bellido, E.; Ferreiro-González, M.; Carrera, C.; Palma, M.; Álvarez, J.Á.; Barbero, G.F.; Ayuso, J. Optimization of Analytical Ultrasound-Assisted Methods for the Extraction of Total Phenolic Compounds and Anthocyanins from Sloes (*Prunus spinosa* L.). *Agronomy* **2020**, *10*, 966. [CrossRef]
2. Aliaño-González, M.J.; Espada-Bellido, E.; Ferreiro-González, M.; Carrera, C.; Palma, M.; Ayuso, J.; Álvarez, J.Á.; Barbero, G.F. Extraction of Anthocyanins and Total Phenolic Compounds from Açai (*Euterpe oleracea* Mart.) Using an Experimental Design Methodology. Part 2: Ultrasound-Assisted Extraction. *Agronomy* **2020**, *10*, 326. [CrossRef]
3. Aliaño-González, M.J.; Ferreiro-González, M.; Espada-Bellido, E.; Carrera, C.; Palma, M.; Ayuso, J.; Barbero, G.F.; Álvarez, J.Á. Extraction of Anthocyanins and Total Phenolic Compounds from Açai (*Euterpe oleracea* Mart.) Using an Experimental Design Methodology. Part 3: Microwave-Assisted Extraction. *Agronomy* **2020**, *10*, 179. [CrossRef]
4. Aliaño-González, M.J.; Ferreiro-González, M.; Espada-Bellido, E.; Carrera, C.; Palma, M.; Álvarez, J.Á.; Ayuso, J.; Barbero, G.F. Extraction of Anthocyanins and Total Phenolic Compounds from Açai (*Euterpe oleracea* Mart.) Using an Experimental Design Methodology. Part 1: Pressurized Liquid Extraction. *Agronomy* **2020**, *10*, 183. [CrossRef]
5. Aourach, M.; González-de-Peredo, A.V.; Vázquez-Espinosa, M.; Essalmani, H.; Palma, M.; Barbero, G.F. Optimization and Comparison of Ultrasound and Microwave-Assisted Extraction of Phenolic Compounds from Cotton-Lavender (*Santolina chamaecyparissus* L.). *Agronomy* **2021**, *11*, 84. [CrossRef]

6. Setyaningsih, W.K.; Nur Fathimah, R.; Nur Cahyanto, M. Process Optimization for Ultrasound-Assisted Starch Production from Cassava (*Manihot esculenta* Crantz) Using Response Surface Methodology. *Agronomy* **2021**, *11*, 117. [CrossRef]
7. Skrypnik, L.; Novikova, A. Response Surface Modeling and Optimization of Polyphenols Extraction from Apple Pomace Based on Nonionic Emulsifiers. *Agronomy* **2020**, *10*, 92. [CrossRef]
8. Catania, P.; Comparetti, A.; De Pasquale, C.; Morello, G.; Vallone, M. Effects of the Extraction Technology on Pomegranate Juice Quality. *Agronomy* **2020**, *10*, 1483. [CrossRef]
9. Scarano, P.; Naviglio, D.; Prigioniero, A.; Tartaglia, M.; Postiglione, A.; Sciarrillo, R.; Guarino, C. Sustainability: Obtaining Natural Dyes from Waste Matrices Using the Prickly Pear Peels of *Opuntia ficus-indica* (L.) Miller. *Agronomy* **2020**, *10*, 528. [CrossRef]
10. Kubczak, M.; Khassenova, A.B.; Skalski, B.; Michlewska, S.; Wielanek, M.; Aralbayeva, A.N.; Murzakhmetova, M.K.; Zamaraeva, M.; Skłodowska, M.; Bryszewska, M.; et al. Bioactive Compounds and Antiradical Activity of the *Rosa canina* L. Leaf and Twig Extracts. *Agronomy* **2020**, *10*, 1897. [CrossRef]
11. Sancho-Galán, P.; Amores-Arrocha, A.; Jiménez-Cantizano, A.; Palacios, V. Physicochemical and Nutritional Characterization of Winemaking Lees: A New Food Ingredient. *Agronomy* **2020**, *10*, 996. [CrossRef]
12. Qi, Z.-Y.; Zhao, J.-Y.; Lin, F.-J.; Wan-Lai Zhou, W.-L.; Gan, R.-Y. Bioactive Compounds, Therapeutic Activities, and Applications of *Ficus pumila* L. *Agronomy* **2021**, *11*, 89. [CrossRef]
13. Vázquez-Espinosa, M.; Fayos, O.; González-de-Peredo, A.V.; Espada-Bellido, E.; Ferreiro-González, M.; Palma, M.; Garcés-Claver, A.; Barbero, G.F. Changes in Capsiate Content in Four Chili Pepper Genotypes (*Capsicum* spp.) at Different Ripening Stages. *Agronomy* **2020**, *10*, 1337. [CrossRef]
14. Vázquez-Espinosa, M.; Olguín-Rojas, J.A.; Fayos, O.; González-de-Peredo, A.V.; Espada-Bellido, E.; Ferreiro-González, M.; Barroso, C.G.; Barbero, G.F.; Garcés-Claver, A.; Palma, M. Influence of Fruit Ripening on the Total and Individual Capsaicinoids and Capsiate Content in Naga Jolokia Peppers (*Capsicum chinense* Jacq.). *Agronomy* **2020**, *10*, 252. [CrossRef]
15. Han, A.-R.; Hong, M.J.; Nam, B.; Kim, B.-R.; Park, H.H.; Baek, I.; Kil, Y.-S.; Nam, J.-W.; Jin, C.H.; Kim, J.-B. Comparison of Flavonoid Profiles in Sprouts of Radiation Breeding Wheat Lines (*Triticum aestivum* L.). *Agronomy* **2020**, *10*, 1489. [CrossRef]
16. Miao, W.; Luo, J.; Liu, J.; Howell, K.; Zhang, P. The Influence of UV on the Production of Free Terpenes in *Vitis vinifera* cv. Shiraz. *Agronomy* **2020**, *10*, 1431. [CrossRef]